document number of reference "N" should read JP 6-318406. Please correct the official record, to ensure that the reference number is properly printed on any patent issuing from this application.

3) Referring to sections 1 and 2 on pages 2 and 3 of the Office Action, the election of the product claims 1 to 7 is affirmed. Non-elected method claims 8 to 15 have been cancelled.

4) A minor typographical error on page 18 of the specification has been corrected. The claims have been amended as follows. Claims 2, 3 and 8 to 15 have been cancelled. The subject matter of claims 2 and 3 has been incorporated into independent claim 1. The claims have been amended to the extent necessary in view of the rejections under 35 U.S.C. §112, first and second paragraphs, as will be discussed below. Marked-up versions of the affected portions of the application are enclosed to show the subject matter of the amendments. The amendments do not introduce any new matter. Entry and consideration of the amendments are respectfully requested.

5) Regarding section 3 on page 3 of the Office Action, claim 5 has been amended to overcome the informality objection. The intended meaning of claim 5 is that the transparent conductive film has a rougher surface (i.e. a greater surface roughness) than the thin film of gold, which has now been more clearly set forth in amended claim 5. This intended meaning and the present amendment are supported in the original specification, e.g. page 5, lines

25 to 33; page 9, line 26 to page 10, line 15; and page 14, lines 11 to 14. Please withdraw the objection to claim 5.

6) Referring to section 4 on pages 3 to 4 of the Office Action, the rejection of claims 2 to 4 and 7 under 35 U.S.C. §112, first paragraph has been taken into account in the present amendment, and is respectfully traversed.

The original specification would have clearly and fully enabled a person of ordinary skill in the art to make and use the invention as now claimed. The subject matter of claim 2 was incorporated into claim 1, which now recites that an Au thin film is arranged on the p-type semiconductor layer, and the n-type transparent conductive film is arranged on the Au thin film. Thus, the Au thin film is interposed between the p-type semiconductor layer and the n-type transparent conductive film.

The Examiner's point (that an n-type semiconductor layer placed on top of a p-type semiconductor layer will become a current blocking layer), is not applicable in the present situation. Namely, the Au film interposed between the p-type semiconductor layer and the n-type conductive film prevents the formation of a p-n junction that would otherwise result if an n-type layer is arranged directly on a p-type layer. Moreover, the Au film is very thin, so as to avoid significantly reducing the light transmittance therethrough (and thus the luminous efficacy of the device).

These features of the inventive arrangement are fully described in the original specification, for example at page 4, line 30 to page 5, line 20, and page 8, line 32 to page 9, line

11. A person of ordinary skill in the art would have been enabled thereby to practice the invention. Accordingly, please withdraw the rejection of claims 2 to 4 and 7 under 35 U.S.C. §112, first paragraph.

7) Referring to section 5 on page 4 of the Office Action, the intended meaning of claim 5 has been clarified as discussed above. Accordingly, please withdraw the rejection of claim 5 under 35 U.S.C. §112, second paragraph.

8) Referring to the bottom of page 4 and top of page 5 of the Office Action, the rejection of claims 1 and 6 as anticipated by U. S. Patent 5,617,446 (Ishibashi et al.) has been obviated by the incorporation of the subject matter of original claims 2 and 3 into claim 1. Please withdraw the anticipation rejection.

9) Referring to the bottom of page 5 to the top of page 7 of the Office Action, the rejection of claims 2 to 5 as obvious over Ishibashi et al. in view of JP 06-318406 (Kazuyoshi et al.) is respectfully traversed, and will be discussed in connection with amended claim 1, which incorporates the subject matter of original claims 2 and 3.

10) Amended claim 1 is directed to a semiconductor light emitting device including a layered structure with a p-type semiconductor layer provided on a light-emitting layer, an Au thin film provided on the p-type semiconductor layer, and an n-type transparent conductive film provided on the Au thin film. Thus, the Au

thin film is arranged between the p-type semiconductor layer and the n-type transparent conductive film. Furthermore, the Au thin film is very thin, namely having a thickness in the range of 1 nm to 3 nm.

11) As discussed above, the inventive layered arrangement is significant for the following reasons. The Au film interposed between the underlying p-type semiconductor layer and the overlying n-type transparent conductive film prevents the formation of a p-n junction between the p-type layer and the n-type film. Thus, junction effects at this location are correspondingly avoided. The Au film is very thin, namely having a thickness in the range from 1 to 3 nm. With such a thickness, the Au film is thick enough to disrupt or prevent the formation of a p-n junction as described above, yet thin enough to avoid significantly reducing the transmittance of light therethrough. The invention thus involves providing an Au film interposed between the p-type semiconductor layer and the n-type transparent conductive film, while setting the Au film thickness based on a balance between opposing considerations. Namely, as described, the film must be thick enough to prevent formation of a p-n junction, but thin enough to avoid significantly reducing the light transmittance therethrough. The prior art neither disclosed nor suggested such a structural arrangement, and would not have provided any motivation toward the presently proposed balance between such competing considerations.

12) Ishibashi et al. disclose a light emitting device with an Au film (14) as an upper surface layer arranged on top of a p-side electrode (13). There is no disclosure or suggestion toward providing an Au film interposed between a p-type semiconductor layer and an n-type transparent conductive film. Moreover, since Ishibashi et al. provide only p-type layers stacked above the active layer (6) and n-type layers stacked below the active layer (6) on the substrate (1), there would have been no suggestion or motivation toward interposing an Au film to prevent the formation of a p-n junction between an n-type transparent conductive film and an adjacent p-type semiconductor layer. In other words, Ishibashi et al. do not even provide an n-type transparent conductive film arranged directly on a p-type semiconductor layer, so there certainly would have been no suggestion and no motivation to provide an Au film interposed between such n-type and p-type layers to achieve the present improved effects.

13) The Examiner further turns to Kazuyoshi et al. for allegedly disclosing an ITO-type transparent conductive layer made of an In and Zn compound. It is noted that Kazuyoshi et al. disclose a transparent conductive film made of an amorphous oxide including In and Zn sputtered onto a transparent base member so as to prepare a conductive transparent base member. Such teachings would have provided no suggestion toward the presently claimed arrangement of an Au film particularly interposed between a p-type semiconductor layer and an n-type transparent conductive film.

14) Even if the teachings of Ishibashi et al. and Kazuyoshi et al. are considered in combination, the present invention would not have been suggested. Neither one of the references suggests anything about providing an Au film interposed between a p-type semiconductor layer and an n-type transparent conductive film. Even if Kazuyoshi et al.'s InO/ZnO layer were incorporated or used in the device according to Ishibashi et al., the result would still have been an Au layer arranged as an upper surface layer on top of the upper p-electrode. Neither reference would have provided any suggestion to position the Au layer at a different location, and particularly to prevent the formation of a p-n junction between a p-type semiconductor layer and an n-type transparent conductive film.

15) Amended independent claim 1 further recites that the Au thin film has a thickness particularly in the range from 1 to 3 nm.

The Examiner admits that the references do not suggest such a thickness of the Au film, but asserts that a selection of the thickness would have involved mere routine optimization within the level of ordinary skill. The Examiner's assertion is respectfully traversed.

The present application has demonstrated that successfully providing an Au film interposed between a p-type semiconductor layer and an n-type transparent conductive film requires a critical balance between competing considerations of film thickness. Namely, the film of Au must be thick enough to prevent formation of a p-n junction, while still being thin enough to avoid any significant reduction in the light transmittance.

The prior art would not even have provided such motivations or considerations, because the prior art made no suggestions toward such an interposed arrangement of an Au thin film in the first place. Thus, a person of ordinary skill in the art was not simply working within a known range of thickness so as to find an optimum result, but rather the person of ordinary skill in the art would have had no motivations toward adjusting the Au film thickness in view of the two competing considerations, in the first place.

Moreover, the prior art films of Au are typically much thicker than the presently claimed Au thin film. For example, as described at page 3, line 9 of the present specification, a typical conventional Au thin film for the purpose of current spreading has a thickness of about 20 nm. That conventional film thickness is about 7 to 20 times thicker than the presently claimed extremely thin film. The references cited by the Examiner would have provided no motivations toward providing anything other than an Au film with a thickness of about 20 nm for the purpose of current spreading (which is the purpose mentioned by Ishibashi et al.).

16) Present dependent claim 5 recites that the transparent conductive film has a rougher surface than the Au thin film. The effect of this is to reduce internal reflection and thereby increase the light extraction out of the device, i.e. to increase the light output, as explained in the present specification, for example at page 5, lines 25 to 33; page 9, line 26 to page 10, line 15; and page 14, lines 11 to 14. The prior art would have provided

no suggestions toward such relatively different surface roughnesses of the layers. The Examiner's assertions regarding a polished semiconductor surface versus a sputtered film surface are also not pertinent to the presently claimed comparative surface roughness. Thus, the invention of claim 5 would not have been obvious.

17) For the above reasons, the Examiner is respectfully requested to withdraw the rejection of claims 2 to 5 as obvious over Ishibashi et al. in view of Kazuyoshi et al.

18) Referring to section 6 on pages 7 to 8 of the Office Action, the rejection of claim 7 as obvious over Ishibashi et al. in view of Kazuyoshi et al., and further in view of U. S. Patent 6,107,641 (Mei et al.) is respectfully traversed. The Examiner has turned to Mei et al. simply for disclosing a laser ablation technique for forming a doped layer. However, claim 7 depends from amended independent claim 1, which has been discussed above in comparison to Ishibashi et al. and Kazuyoshi et al. The additional disclosure of Mei et al. when combined with the two above references would not have suggested the special combination of features of present independent claim 1. Thus, claim 7 dependent therefrom must also be patentable. Please withdraw the rejection of claim 7 as obvious.

19) Favorable reconsideration and allowance of the application, including all present claims 1 and 4 to 7, are respectfully requested.

Respectfully submitted,

Takao NAKAMURA et al.
Applicant

By _____
Walter F. Fasse
Patent Attorney
Reg. No.: 36132
Tel. 207-862-4671
Fax. 207-862-4681
P. O. Box 726
Hampden, ME 04444-0726

WFF:ar/3905
Encls.:postcard, marked-up version of spec. pgs. 17, 18; marked-up version of amended claims 1, 4, 5, 7

CERTIFICATE OF MAILING:

I hereby certify that this correspondence with all enclosures is being mailed on September 6, 2001 as first-class mail, postage pre-paid, in an envelope addressed to: Commissioner for Patents, Box Response - No Fee, Washington, D. C. 20231.

_____ 9/6/01
Walter F. Fasse - September 6, 2001

"marked-up Version of Spec. Pgs. 17 + 18

formed as a p electrode of a ZnSe LED. In order to avoid this, an IDIXO/Au structure obtained by forming an Au film before forming an IDIXO film was studied. Table 6 shows results in relation to resistivity.

Table 6

Thickness of Au Film	Resistivity
3nm	$1.2\times10^{-4}\Omega$cm
10nm	$6.0\times10^{-5}\Omega$cm

As compared with a smooth glass substrate, slightly higher resistivity was obtained when the thickness of the Au film was 3 nm, and substantially identical resistivity was obtained when the thickness was 10 nm. When the thickness of the Au film was 3 nm, the resistivity was increased conceivably because no continuous film of IDIXO was grown in an initial stage due to the presence of Au (not contributing to electrical conduction) grown in the form of an island. When the thickness of the Au film was 10 nm, Au formed a continuous film to compensate for reduction of electrical conduction of IDIXO.

Fig. 7 shows transmittance in IDIXO/Au electrode structures. Reduction of transmittance resulting from the presence of Au is recognized. At a wavelength of 500 nm, the transmittance of the sample of IDIXO (120 nm)/Au (3 nm) is about 80 %. The transmittance was reduced as compared with the small thickness of the Au film conceivably because the transmittance of the IDIXO film itself was reduced due to the presence of Au.

Fourth Embodiment

Fig. 8 is a sectional view of a compound semiconductor light-emitting device manufactured with application of the method of manufacturing a transparent conductor film according to the third embodiment of the present invention. Referring to Fig. 8, an n electrode 52 is provided on the back surface of an n-type semiconductor layer 51. An active layer 53 is provided on the n-type semiconductor layer 51. A p-type semiconductor layer 54 is provided on the active layer 53. A contact layer 55 is provided

on the p-type semiconductor layer 54. A p electrode 56, which is a transparent electrode, is provided on the contact layer 55. A pad 57 is provided on the p electrode 56. A current is fed to the pad 57 from an external power source (not shown) through a wire 58.

When employing the laser ablation described with reference to the third embodiment as the method of forming the transparent electrode 56 of the compound semiconductor light-emitting device shown in Fig. 8, an electrode having high transmittance, low electrical conductivity and optical output of at least twice that of a conventional Au electrode is obtained. A ZnSe LED preferably has an electrode structure of IDIXO (200 nm)/Au (3 nm), in order to maximize the optical output.

The method of manufacturing a transparent conductor film having the aforementioned structure is not only applied to a method of forming a transparent electrode of a compound semiconductor light-emitting device but also employable in various fields of liquid crystal displays, solar batteries and the like.

Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of the present invention being limited only by the terms of the appended claims.

Docket #3905
USSN: 09/519,408
A.U.: 2814

Marked-up Version of Claims 1, 4, 5, 7

WHAT IS CLAIMED IS:

(amended)

1. A semiconductor light-emitting device comprising:

a substrate [provided with] and an n-type lower electrode provided on [the] a back surface of said substrate;

a light-emitting layer provided on said substrate;

a p-type semiconductor layer provided on said light-emitting layer;

[and]

an [upper electrode] Au thin film, provided on said p-type semiconductor layer and having a thickness of 1nm to 3nm; and [wherein]

[said upper electrode has a multilayer structure consisting of at least two heterogeneous layers.] an n-type transparent conductive film provided on said Au thin film, with said Au thin film between said p-type semiconductor layer and said n-type transparent conductive film.

(amended)

4. The semiconductor light-emitting device according to claim 2, wherein said transparent conductive film is made of In_2O_3–10 wt.% ZnO.

(amended)

5. The semiconductor light-emitting device according to claim 1, wherein said [upper electrode has a multilayer structure including an upper layer and a lower layer,] n-type transparent conductive film has a surface with a first surface roughness that is greater than a second surface roughness of a surface of said Au thin film.

[the surface of said upper layer is flattened, and

the surface of said upper layer is irregularized.]

(amended)

7. The semiconductor light-emitting device according to claim 4, wherein said transparent conductive film of In_2O_3–10 wt.% ZnO is formed by laser ablation.